

**MACHINE FOR THE PREPARATION OF BEVERAGES****RELATED APPLICATION**

This application claims priority from U.S. provisional  
5 patent application No. 60/462,538, filed April 11, 2003,  
which is hereby incorporated by reference.

**BACKGROUND**

The present invention relates to a machine for the  
10 preparation of beverages and, in particular, for use with  
sealed cartridges which are formed from substantially air-  
and water-impermeable materials and which contain one or  
more ingredients for the preparation of beverages.

It has previously been proposed to seal beverage  
15 preparation ingredients in individual air-impermeable  
packages for use in beverage machines. For example,  
cartridges or capsules containing compacted ground coffee  
are known for use in certain coffee preparation machines  
which are generally termed "espresso" machines. In the  
20 production of coffee using these preparation machines the  
coffee cartridge is placed in a brewing chamber and hot  
water is passed through the cartridge at relatively high  
pressures, thereby extracting the aromatic coffee  
constituents from the ground coffee to produce the coffee  
25 beverage. Typically, such machines operate at a pressure of  
greater than  $6 \times 10^5$  Pa. The preparation machines of the type  
described have to date been relatively expensive since  
components of the machine, such as the water pumps and  
seals, must be able to withstand the high pressures.

30 In WO01/58786 there is described a cartridge for the  
preparation of beverages which operates at a pressure

generally in the range  $0.7$  to  $2.0 \times 10^5$  Pa. However, the cartridge is designed for use in a beverage preparation machine for the commercial or industrial market and is relatively expensive. Hence, there remains a requirement  
5 for a cartridge for the preparation of beverages wherein the cartridges and beverage preparation machine are suitable, in particular, for the domestic market in terms of cost, performance and reliability. There is also a need for a beverage preparation machine for such cartridges which is  
10 simple to operate and reliable in operation.

#### SUMMARY

Accordingly, the present invention provides a low pressure beverage preparation system for automatically  
15 preparing a range of beverage types from a range of beverage cartridges, the system comprising:

a beverage preparation machine;  
and a plurality of beverage cartridges, each  
beverage cartridge containing one or more beverage  
20 ingredients associated with a specific beverage type,  
wherein the beverage preparation system comprises:  
a. means for receiving one of said plurality of  
beverage cartridges in said beverage  
preparation machine and means for supplying,  
25 in use, to said beverage cartridge an  
aqueous medium at a pressure of less than 2  
bar to produce a beverage from the one or  
more beverage ingredients contained therein;  
b. a reader in said beverage preparation  
30 machine for automatically interpreting a  
code written on said beverage cartridge;

- c. processing means for creating a specific brewing cycle based on said code;
- d. means for automatically adjusting a temperature of said aqueous medium based on said code prior to supply of said aqueous medium to the beverage cartridge;
- 5 e. means in at least some of said plurality of beverage cartridges for optionally, dependant on beverage type, producing foaming of the beverage; and
- 10 f. a user interface for initiating an operating cycle;

wherein the beverage preparation system can produce a range of beverage types including at least, but not limited 15 to, filtered coffee, cappuccino, tea, chocolate and frothed milk, and wherein operation of the user interface is independent of the beverage type being dispensed.

Advantageously, the beverage preparation machine of the present invention is simple to operate. In particular the 20 same method of operation is used by a consumer irrespective of the beverage type to be dispensed.

It will be understood that by the term "cartridge" as used herein is meant any package, container, sachet or receptacle which contains one or more beverage ingredients 25 in the manner described. The cartridge may be rigid, semi-rigid or flexible.

The cartridge for use in the present system may contain one or more beverage ingredients suitable for the formation of a beverage product. The beverage product may be, for 30 example, one of coffee, tea, chocolate or a dairy-based beverage including milk. The beverage ingredients may be

powdered, ground, leaf-based or liquid. The beverage ingredients may be insoluble or soluble. Examples include roast and ground coffee, leaf tea, powdered cocoa solids and soup, liquid milk-based beverages and concentrated fruit 5 juices.

Preferably, the range of beverage types includes coffee, tea, chocolate, milk, soup and fruit juices.

Preferably, the beverage preparation machine further comprises means for purging the beverage cartridge after 10 dispensing of the beverage.

The system may also be used with one or more cartridges comprising one or more non-beverage ingredients, for preparation of non-beverage products, such as sauces and desserts.

15 The reader may be an optical bar code reader.

The system may be a domestic low pressure beverage preparation system.

The present invention also provides a method of preparing at least one of a range of beverages comprising 20 the steps of:

- a. inserting at least one beverage cartridge containing one or more beverage ingredients into a low pressure beverage preparation machine;
- b. operating a user interface of said beverage preparation machine to initiate an operating cycle;
- c. operating a reader to detect a code written on said beverage cartridge;
- d. creating a specific brewing cycle based on said code;
- e. passing an aqueous medium through the beverage 30 cartridge to produce a beverage, wherein the

temperature, pre-wet, volume, flow rate and air purge of the aqueous medium is set based on the code;

f. for at least some of the range of beverages, producing foaming of the beverage;

5 wherein the method can produce a range of beverage type using one or more beverage cartridges including at least, but not limited to, filtered coffee, cappuccino, tea, chocolate and frothed milk, and wherein operation of the user interface is independent of the beverage type being 10 dispensed.

The present invention also provides a method of preparing a beverage comprising the steps of:

a. inserting a first beverage cartridge containing 15 one or more beverage ingredients into a beverage preparation machine;

b. operating said beverage preparation machine to pass an aqueous medium through the first beverage cartridge at a pressure of less than 2 bar to dispense a first portion of said beverage 20 into a receptacle;

c. storing in a memory of said beverage preparation machine information on the type of the first beverage cartridge;

d. inserting a second beverage cartridge containing 25 one or more beverage ingredients into the beverage preparation machine; and

e. operating the beverage preparation machine to pass an aqueous medium through the second beverage cartridge at a pressure of less than 2 bar to dispense a second portion of said 30 beverage into the receptacle;

wherein one or more operating parameters of the beverage preparation machine during dispensing of the second beverage cartridge are set with reference to the information stored in the memory on the type of the first beverage cartridge.

5 Optionally, the method further comprises using additional beverage cartridges to dispense three or more portions of a beverage.

10 Preferably, the one or more operating parameters include:

- I. the temperature of the aqueous medium passed through the beverage cartridge;
- II. the flow rate of the aqueous medium;
- 15 III. the presence or absence of a pre-wet stage;
- IV. the presence of absence of an air-purge stage;
- V. the pressure of the aqueous medium; and/or
- VI. the total volume of aqueous medium dispensed.

20 In the following description the terms "upper" and "lower" and equivalents will be used to describe the relational positioning of features of the invention. The terms "upper" and "lower" and equivalents should be understood to refer to the cartridge (or other components) in its normal orientation for insertion into a beverage preparation machine and subsequent dispensing as shown, for example, in Figure 4. In particular, "upper" and "lower" refer, respectively, to relative positions nearer or further from a top surface 11 of the cartridge. In addition, the terms "inner" and "outer" and equivalents will be used to 25 describe the relational positioning of features of the invention. The terms "inner" and "outer" and equivalents 30

should be understood to refer to relative positions in the cartridge (or other components) being, respectively, nearer or further from a centre or major axis X of the cartridge 1 (or other component).

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BRIEF DESCRIPTION OF THE DRAWINGS

Embodiments of the present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

10 Figure 1 is cross-sectional drawing of an outer member of first and second embodiments of cartridge for use with the present invention;

Figure 2 is a cross-sectional drawing of a detail of the outer member of Figure 1 showing an inwardly directed cylindrical extension;

15 Figure 3 is a cross-sectional drawing of a detail of the outer member of Figure 1 showing a slot;

Figure 4 is a perspective view from above of the outer member of Figure 1;

20 Figure 5 is a perspective view from above of the outer member of Figure 1 in an inverted orientation;

Figure 6 is a plan view from above of the outer member of Figure 1;

25 Figure 7 is a cross-sectional drawing of an inner member of the first embodiment of cartridge;

Figure 8 is a perspective view from above of the inner member of Figure 7;

Figure 9 is a perspective view from above of the inner member of Figure 7 in an inverted orientation;

30 Figure 10 is a plan view from above of the inner member of Figure 7;

Figure 11 is a cross-sectional drawing of the first embodiment of cartridge in an assembled condition;

Figure 12 is a cross-sectional drawing of an inner member of the second embodiment of cartridge;

5 Figure 13 is a cross-sectional drawing of a detail of the inner member of Figure 12 showing an aperture;

Figure 14 is a perspective view from above of the inner member of Figure 12;

10 Figure 15 is a perspective view from above of the inner member of Figure 12 in an inverted orientation;

Figure 16 is another cross-sectional drawing of the inner member of Figure 12;

15 Figure 17 is a cross-sectional drawing of another detail of the inner member of Figure 12 showing an air inlet;

Figure 18 is a cross-sectional drawing of the second embodiment of cartridge in an assembled condition;

20 Figure 19 is cross-sectional drawing of an outer member of third and fourth embodiments of cartridge for use with the present invention;

Figure 20 is a cross-sectional drawing of a detail of the outer member of Figure 19 showing an inwardly directed cylindrical extension;

25 Figure 21 is a plan view from above of the outer member of Figure 19;

Figure 22 is a perspective view from above of the outer member of Figure 19;

Figure 23 is a perspective view from above of the outer member of Figure 19 in an inverted orientation;

30 Figure 24 is a cross-sectional drawing of an inner member of the third embodiment of cartridge;

Figure 25 is a plan view from above of the inner member of Figure 24;

Figure 26 is a cross-sectional drawing of a detail of the inner member of Figure 24 showing an in-turned upper 5 rim;

Figure 27 is a perspective view from above of the inner member of Figure 24;

Figure 28 is a perspective view from above of the inner member of Figure 24 in an inverted orientation;

10 Figure 29 is a cross-sectional drawing of the third embodiment of cartridge in an assembled condition;

Figure 30 is a cross-sectional drawing of an inner member of the fourth embodiment of cartridge;

Figure 31 is a plan view from above of the inner member 15 of Figure 30;

Figure 32 is a perspective view from above of the inner member of Figure 30;

Figure 33 is a perspective view from above of the inner member of Figure 30 in an inverted orientation;

20 Figure 34 is a cross-sectional drawing of the fourth embodiment of cartridge in an assembled condition;

Figure 35 is a front perspective view of a beverage preparation machine according to the present invention;

Figure 36 is a front perspective view of the machine of 25 Figure 35 with a cartridge head in an open position;

Figure 37 is a rear perspective view of the machine of Figure 35 with some parts omitted for clarity;

Figure 38 is another rear perspective view of the machine of Figure 35 with some parts omitted for clarity;

Figure 39 is a perspective view of the cartridge head of the machine of Figure 35 with some parts omitted for clarity;

5 Figure 40 is another perspective view of the cartridge head of the machine of Figure 35 with some parts omitted for clarity;

Figure 41 is a cross-sectional view of the cartridge head in a closed position;

10 Figure 42 is a cross-sectional view of the cartridge head in an open position;

Figure 43 is a schematic layout of the machine of Figure 35;

Figure 44a and 44b are schematic layouts of first and second code recognition means for the machine of Figure 35;

15 Figure 45 is a plan view of a beverage of the present invention comprising a barcode.

Figure 46a is a graph of concentration vs. operating cycle time;

20 Figure 46b is a graph of foamability vs. operating cycle time; and

Figure 46c is a graph of temperature vs. operating cycle time.

#### DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

25 As shown in Figure 11, the cartridge 1 for use with the present invention generally comprises an outer member 2, an inner member 3 and a laminate 5. The outer member 2, inner member 3 and laminate 5 are assembled to form the cartridge 1 which has an interior 120 for containing one or more 30 beverage ingredients, an inlet 121, an outlet 122 and a beverage flow path linking the inlet 121 to the outlet 122

and which passes through the interior 120. The inlet 121 and outlet 122 are initially sealed by the laminate 5 and are opened in use by piercing or cutting of the laminate 5. The beverage flow path is defined by spatial inter-  
5 relationships between the outer member 2, inner member 3 and laminate 5 as discussed below. Other components may optionally be included in the cartridge 1, such as a filter 4, as will be described further below.

A first version of cartridge 1 which will be described  
10 for background purposes is shown in Figures 1 to 11. The first version of the cartridge 1 is particularly designed for use in dispensing filtered products such as roast and ground coffee or leaf tea. However, this version of the cartridge 1 and the other versions described below may be  
15 used with other products such as chocolate, coffee, tea, sweeteners, cordials, flavourings, alcoholic beverages, flavoured milk, fruit juices, squashes, sauces and desserts.

As can be seen from Figure 5, the overall shape of the cartridge 1 is generally circular or disc-shaped with the  
20 diameter of the cartridge 1 being significantly greater than its height. A major axis X passes through the centre of the outer member as shown in Figure 1. Typically the overall diameter of the outer member 2 is 74.5 mm  $\pm$ 6mm and the overall height is 16 mm  $\pm$ 3mm. Typically the volume of the  
25 cartridge 1 when assembled is 30.2 ml  $\pm$ 2%.

The outer member 2 generally comprises a bowl-shaped shell 10 having a curved annular wall 13, a closed top 11 and an open bottom 12. The diameter of the outer member 2 is smaller at the top 11 compared to the diameter at the bottom  
30 12, resulting from a flaring of the annular wall 13 as one traverses from the closed top 11 to the open bottom 12. The

annular wall 13 and closed bottom 11 together define a receptacle having an interior 34.

A hollow inwardly directed cylindrical extension 18 is provided in the closed top 11 centred on the major axis X.

5 As more clearly shown in Figure 2, the cylindrical extension 18 comprises a stepped profile having first, second and third portions 19, 20 and 21. The first portion 19 is right circular cylindrical. The second portion 20 is frusto-conical in shape and is inwardly tapered. The third portion 10 21 is another right circular cylinder and is closed off by a lower face 31. The diameter of the first, second and third portion 19, 20 and 21 incrementally decreases such that the diameter of the cylindrical extension 18 decreases as one traverses from the top 11 to the closed lower face 31 of the 15 cylindrical extension 18. A generally horizontal shoulder 32 is formed on the cylindrical extension 18 at the junction between the second and third portions 20 and 21.

An outwardly extending shoulder 33 is formed in the outer member 2 towards the bottom 12. The outwardly 20 extending shoulder 33 forms a secondary wall 15 co-axial with the annular wall 13 so as to define an annular track forming a manifold 16 between the secondary wall 15 and the annular wall 13. The manifold 16 passes around the circumference of the outer member 2. A series of slots 17 25 are provided in the annular wall 13 level with the manifold 16 to provide gas and liquid communication between the manifold 16 and the interior 34 of the outer member 2. As shown in Figure 3, the slots 17 comprise vertical slits in the annular wall 13. Between 20 and 40 slots are provided. 30 In the embodiment shown thirty-seven slots 17 are provided generally equi-spaced around the circumference of the

manifold 16. The slots 17 are preferably between 1.4 and 1.8 mm in length. Typically the length of each slot is 1.6 mm representing 10% of the overall height of the outer member 2. The width of each slot is between 0.25 and 0.35 mm.

5 Typically, the width of each slot is 0.3 mm. The width of the slots 17 is sufficiently narrow to prevent the beverage ingredients passing therethrough into the manifold 16 either during storage or in use.

An inlet chamber 26 is formed in the outer member 2 at 10 the periphery of the outer member 2. A cylindrical wall 27 is provided, as most clearly shown in Figure 5, which defines the inlet chamber 26 within, and partitions the inlet chamber 26 from, the interior 34 of the outer member 2. The cylindrical wall 27 has a closed upper face 28 which 15 is formed on a plane perpendicular to the major axis X and an open lower end 29 co-planar with the bottom 12 of the outer member 2. The inlet chamber 26 communicates with the manifold 16 via two slots 30 as shown in Figure 1. Alternatively, between one and four slots may be used to 20 communicate between the manifold 16 and the inlet chamber 26.

A lower end of the outwardly extending shoulder 33 is provided with an outwardly extending flange 35 which extends perpendicularly to the major axis X. Typically the flange 35 25 has a width of between 2 and 4 mm. A portion of the flange 35 is enlarged to form a handle 24 by which the outer member 2 may be held. The handle 24 is provided with an upturned rim 25 to improve grip.

The outer member 2 is formed as a single integral piece 30 from high density polyethylene, polypropylene, polystyrene, polyester, or a laminate of two or more of these materials.

A suitable polypropylene is the range of polymers available from DSM UK Limited (Redditch, United Kingdom). The outer member may be opaque, transparent or translucent. The manufacturing process may be injection moulding.

5 The inner member 3 as shown in Figures 7 to 10, comprises an annular frame 41 and a downwardly extending cylindrical funnel 40. A major axis X passes through the centre of the inner member 3 as shown in Figure 7.

As best shown in Figure 8, the annular frame 41 10 comprises an outer rim 51 and an inner hub 52 joined by ten equi-spaced radial spokes 53. The inner hub 52 is integral with and extends from the cylindrical funnel 40. Filtration apertures 55 are formed in the annular frame 41 between the radial spokes 53. A filter 4 is disposed on the annular 15 frame 41 so as to cover the filtration apertures 55. The filter is preferably made from a material with a high wet strength, for example a non-woven fibre material of polyester. Other materials which may be used include a water-impermeable cellulosic material, such as a cellulosic 20 material comprising woven paper fibres. The woven paper fibres may be admixed with fibres of polypropylene, polyvinyl chloride and/or polyethylene. The incorporation of these plastic materials into the cellulosic material renders the cellulosic material heat-sealable. The filter 4 25 may also be treated or coated with a material which is activated by heat and/or pressure so that it can be sealed to the annular frame 41 in this way.

As shown in the cross-sectional profile of Figure 7, the inner hub 52 is located at a lower position than the 30 outer rim 51, resulting in the annular frame 41 having a sloping lower profile.

The upper surface of each spoke 53 is provided with an upstanding web 54 which divides a void space above the annular frame 41 into a plurality of passages 57. Each passage 57 is bounded on either side by a web 54 and on a lower face by the filter 4. The passages 57 extend from the outer rim 51 downwardly towards, and open into, the cylindrical funnel 40 at openings 56 defined by the inner extremities of the webs 54.

The cylindrical funnel 40 comprises an outer tube 42 surrounding an inner discharge spout 43. The outer tube 42 forms the exterior of the cylindrical funnel 40. The discharge spout 43 is joined to the outer tube 42 at an upper end of the discharge spout 43 by means of an annular flange 47. The discharge spout 43 comprises an inlet 45 at an upper end which communicates with the openings 56 of the passages 57 and an outlet 44 at a lower end through which the prepared beverage is discharged into a cup or other receptacle. The discharge spout 43 comprises a frusto-conical portion 48 at an upper end and a cylindrical portion 58 at a lower end. The cylindrical portion 58 may have a slight taper such that it narrows towards the outlet 44. The frusto-conical portion 48 helps to channel beverage from the passages 57 down towards the outlet 44 without inducing turbulence to the beverage. An upper surface of the frusto-conical portion 48 is provided with four support webs 49 equi-spaced around the circumference of the cylindrical funnel 40. The support webs 49 define channels 50 therebetween. The upper edges of the support webs 49 are level with one another and perpendicular to the major axis

30 X.

The inner member 3 may be formed as a single integral piece from polypropylene or a similar material as described above and by injection moulding in the same manner as the outer member 2.

5 Alternatively, the inner member 3 and/or the outer member 2 may be made from a biodegradable polymer. Examples of suitable materials include degradable polyethylene (for example, SPITEK supplied by Symphony Environmental, Borehamwood, United Kingdom), biodegradable polyester amide 10 (for example, BAK 1095 supplied by Symphony Environmental), poly lactic acids (PLA supplied by Cargil, Minnesota, USA), starch-based polymers, cellulose derivatives and polypeptides.

The laminate 5 is formed from two layers, a first layer 15 of aluminium and a second layer of cast polypropylene. The aluminium layer is between 0.02 and 0.07 mm in thickness. The cast polypropylene layer is between 0.025 and 0.065 mm in thickness. In one embodiment the aluminium layer is 0.06 mm and the polypropylene layer is 0.025 mm thick. This 20 laminate is particularly advantageous as it has a high resistance to curling during assembly. As a result the laminate 5 may be pre-cut to the correct size and shape and subsequently transferred to the assembly station on the production line without undergoing distortion. Consequently, 25 the laminate 5 is particularly well suited to welding. Other laminate materials may be used including PET/Aluminium/PP, PE/EVOH/PP, PET/metallised/PP and Aluminium/PP laminates. Roll laminate stock may be used instead of die cut stock.

The cartridge 1 may be closed by a rigid or semi-rigid 30 lid instead of a flexible laminate.

Assembly of the cartridge 1 involves the following steps:

- a) the inner member 3 is inserted into the outer member 2;
- 5 b) the filter 4 is cut to shape and placed onto the inner member 3 so to be received over the cylindrical funnel 40 and come to rest against the annular frame 41;
- 10 c) the inner member 3, outer member 2 and filter 4 are joined by ultrasonic welding;
- d) the cartridge 1 is filled with one or more beverage ingredients;
- e) the laminate 5 is affixed to the outer member 2.

These steps will be discussed in greater detail below.

15 The outer member 2 is orientated with the open bottom 12 directed upwards. The inner member 3 is then inserted into the outer member 2 with the outer rim 51 being received as a loose fit in an axial extension 14 at top 11 of the cartridge 1. The cylindrical extension 18 of the outer 20 member 2 is at the same time received in the upper portion of the cylindrical funnel 40 of the inner member 3. The third portion 21 of the cylindrical extension 18 is seated inside the cylindrical funnel 40 with the closed lower face 31 of the cylindrical extension 18 bearing against the 25 support webs 49 of the inner member 3. The filter 4 is then placed over the inner member 3 such that the filter material contacts the annular rim 51. An ultrasonic welding process is then used to join the filter 4 to the inner member 3 and at the same time, and in the same process step, the inner 30 member 3 to the outer member 2. The inner member 3 and filter 4 are welded around the outer rim 51. The inner

member 3 and outer member 2 are joined by means of weld lines around the outer rim 51 and also the upper edges of the webs 54.

As shown most clearly in Figure 11, the outer member 2 and inner member 3 when joined together define a void space 130 in the interior 120 below the annular flange 41 and exterior the cylindrical funnel 40 which forms a filtration chamber. The filtration chamber 130 and passages 57 above the annular frame 41 are separated by the filter paper 4.

10 The filtration chamber 130 contains the one or more beverage ingredients 200. The one or more beverage ingredients are packed into the filtration chamber 130. For a filtered style beverage the ingredient is typically roast and ground coffee or leaf tea. The density of packing of the 15 beverage ingredients in the filtration chamber 130 can be varied as desired. Typically, for a filtered coffee product the filtration chamber contains between 5.0 and 10.2 grams of roast and ground coffee in a filtration bed of thickness of typically 5 to 14 mm. Optionally, the interior 120 may 20 contain one or more bodies, such as spheres, which are freely movable within the interior 120 to aid mixing by inducing turbulence and breaking down deposits of beverage ingredients during discharge of the beverage.

The laminate 5 is then affixed to the outer member 2 by 25 forming a weld 126 around the periphery of the laminate 5 to join the laminate 5 to the lower surface of the outwardly extending flange 35. The weld 126 is extended to seal the laminate 5 against the lower edge of the cylindrical wall 27 of the inlet chamber 26. Further, a weld 125 is formed 30 between the laminate 5 and the lower edge of the outer tube 42 of the cylindrical funnel 40. The laminate 5 forms the

lower wall of the filtration chamber 130 and also seals the inlet chamber 26 and cylindrical funnel 40. However, a small gap 123 exists prior to dispensation between the laminate 5 and the lower edge of the discharge spout 43. A variety of 5 welding methods may be used, such as heat and ultrasonic welding, depending on the material characteristics of the laminate 5.

Advantageously, the inner member 3 spans between the outer member 2 and the laminate 5. The inner member 3 is 10 formed from a material of relative rigidity, such as polypropylene. As such, the inner member 3 forms a load-bearing member that acts to keep the laminate 5 and outer member 2 spaced apart when the cartridge 1 is compressed. It is preferred that the cartridge 1 is subjected to a 15 compressive load of between 130 and 280N in use. The compressive force acts to prevent the cartridge failing under internal pressurisation and also serves to squeeze the inner member 3 and outer member 2 together. This ensures that the internal dimensions of passageways and apertures in 20 the cartridge 1 are fixed and unable to change during pressurisation of the cartridge 1.

To use the cartridge 1 it is first inserted into a beverage preparation machine (which will be described in further detail below) and the inlet 121 and outlet 122 are 25 opened by piercing members of the beverage preparation machine which perforate and fold back the laminate 5. An aqueous medium, typically water, under pressure enters the cartridge 1 through the inlet 121 into the inlet chamber 26 at a pressure of between 0.1-2.0 bar, although higher 30 pressures may be used with the cartridges of the present invention. From there the water is directed to flow through

the slots 30 and round the manifold 16 and into the filtration chamber 130 of the cartridge 1 through the plurality of slots 17. The water is forced radially inwardly through the filtration chamber 130 and mixes with 5 the beverage ingredients 200 contained therein. The water is at the same time forced upwardly through the beverage ingredients. The beverage formed by passage of the water through the beverage ingredients passes through the filter 4 and filtration apertures 55 into the passages 57 lying above 10 the annular frame 41. The sealing of the filter 4 onto the spokes 53 and the welding of the rim 51 with the outer member 2 ensures that there are no short-circuits and all the beverage has to pass through the filter 4.

The beverage then flows downwardly along the radial 15 passages 57 formed between the webs 54 and through the openings 56 and into the cylindrical funnel 40. The beverage passes along the channels 50 between the support webs 47 and down the discharge spout 43 to the outlet 44 where the beverage is discharged into a receptacle such as a cup.

20 Preferably, the beverage preparation machine comprises an air purge facility, wherein compressed air is forced through the cartridge 1 at the end of the operating cycle to flush out the remaining beverage into the receptacle.

A second version of cartridge 1 is shown in Figures 12 25 to 18. The second version of the cartridge 1 is particularly designed for use in dispensing espresso-style products such as roast and ground coffee where it is desirable to produce a beverage having a froth of tiny bubbles known as a crema. Many of the features of the second version of the cartridge 30 1 are the same as in the first version and like numerals have been used to reference like features. In the following

description the differences between the first and second versions will be discussed. Common features which function in the same manner will not be discussed in detail.

The outer member 2 is of the same construction as in 5 the first version of cartridge 1 and as shown in Figures 1 to 6.

The annular frame 41 of the inner member 3 is the same as in the first version. Also, a filter 4 is disposed on the annular frame 41 so as to cover the filtration apertures 10 55. The outer tube 42 of the cylindrical funnel 40 is also as before. However, there are a number of differences in the construction of the inner member 2 of the second version compared to the first version. As shown in Figure 16, the 15 discharge spout 43 is provided with a partition 65 which extends part way up the discharge spout 43 from the outlet 44. The partition 65 helps to prevent the beverage spraying and/or splashing as it exits the discharge spout 43. The profile of the discharge spout 43 is also different and comprises a stepped profile with a distinct dog-leg 66 near 20 an upper end of the tube 43.

A rim 67 is provided upstanding from the annular flange 47 joining the outer tube 42 to the discharge spout 43. The rim 67 surrounds the inlet 45 to the discharge spout 43 and defines an annular channel 69 between the rim 67 and the 25 upper portion of the outer tube 42. The rim 67 is provided with an inwardly directed shoulder 68. At one point around the circumference of the rim 67 an aperture 70 is provided in the form of a slot which extends from an upper edge of rim 67 to a point marginally below the level of the shoulder 30 68 as most clearly shown in Figures 12 and 13. The slot has a width of 0.64 mm.

An air inlet 71 is provided in annular flange 47 circumferentially aligned with the aperture 70 as shown in Figures 16 and 17. The air inlet 71 comprises an aperture passing through the flange 47 so as to provide communication 5 between a point above the flange 47 and the void space below the flange 47 between the outer tube 42 and discharge spout 43. Preferably, and as shown, the air inlet 71 comprises an upper frusto-conical portion 73 and a lower cylindrical portion 72. The air inlet 71 is typically formed by a mould 10 tool such as a pin. The tapered profile of the air inlet 71 allows the mould tool to be more easily removed from the moulded component. The wall of the outer tube 42 in the vicinity of the air inlet 71 is shaped to form a chute 75 leading from the air inlet 71 to the inlet 45 of the 15 discharge spout 43. As shown in Figure 17, a canted shoulder 74 is formed between the air inlet 71 and the chute 75 to ensure that the jet of beverage issuing from the slot 70 does not immediately foul on the upper surface of the flange 47 in the immediate vicinity of the air inlet 71.

20 The assembly procedure for the second version of cartridge 1 is similar to the assembly of the first version. However, there are certain differences. As shown in Figure 18, the third portion 21 of the cylindrical extension 18 is seated inside the support rim 67 rather than against support 25 webs. The shoulder 32 of the cylindrical extension 18 between the second portion 20 and third portion 21 bears against the upper edge of the support rim 67 of the inner member 3. An interface zone 124 is thus formed between the inner member 3 and the outer member 2 comprising a face seal 30 between the cylindrical extension 18 and the support rim 67 which extends around nearly the whole circumference of the

cartridge 1. The seal between the cylindrical extension 18 and the support rim 67 is not fluid-tight though since the slot 70 in the support rim 67 extends through the support rim 67 and downwardly to a point marginally below the shoulder 68. Consequently the interface fit between the cylindrical extension 18 and the support rim 67 transforms the slot 70 into an aperture 128, as most clearly shown in Figure 18, providing gas and liquid communication between the annular channel 69 and the discharge spout 43. The aperture is typically 0.64 mm wide by 0.69 mm long.

Operation of the second version of cartridge 1 to dispense a beverage is similar to the operation of the first version but with certain differences. Beverage in the radial passages 57 flows downwardly along the passages 57 formed between the webs 54 and through the openings 56 and into the annular channel 69 of the cylindrical funnel 40. From the annular channel 69 the beverage is forced under pressure through the aperture 128 by the back pressure of beverage collecting in the filtration chamber 130 and passages 57. The beverage is thus forced through aperture 128 as a jet and into an expansion chamber formed by the upper end of the discharge spout 43. As shown in Figure 18, the jet of beverage passes directly over the air inlet 71. As the beverage enters the discharge spout 43 the pressure of the beverage jet drops. As a result air is entrained into the beverage stream in the form of a multitude of small air bubbles as the air is drawn up through the air inlet 71. The jet of beverage issuing from the aperture 128 is funnelled downwards to the outlet 44 where the beverage is discharged into a receptacle such as a cup where the air bubbles form the desired crema. Thus, the aperture 128 and

the air inlet 71 together form an eductor which acts to entrain air into the beverage. Flow of beverage into the eductor should be kept as smooth as possible to reduce pressure losses. Advantageously, the walls of the eductor 5 should be made concave to reduce losses due to 'wall effect' friction. The dimensional tolerance of the aperture 128 is small. Preferably the aperture size is fixed plus or minus 0.02 mm<sup>2</sup>. Hairs, fibrils or other surface irregularities can be provided within or at the exit of the eductor to increase 10 the effective cross-sectional area which has been found to increase the degree of air entrainment.

A third version of cartridge 1 is shown in Figures 19 to 29. The third version of the cartridge 1 is particularly designed for use in dispensing soluble products which may be 15 in powdered, liquid, syrup, gel or similar form. The soluble product is dissolved by or forms a suspension in, an aqueous medium such as water when the aqueous medium is passed, in use, through the cartridge 1. Examples of beverages include chocolate, coffee, milk, tea, soup or other rehydratable or 20 aqueous-soluble products. Many of the features of the third version of the cartridge 1 are the same as in the previous versions and like numerals have been used to reference like features. In the following description the differences between the third and previous versions will be discussed. 25 Common features which function in the same manner will not be discussed in detail.

Compared to the outer member 2 of the previous versions, the hollow inwardly directed cylindrical extension 18 of the outer member 2 of the third version has a larger 30 overall diameter as shown in Figure 20. In particular the diameter of the first portion 19 is typically between 16 and

18 mm compared to 13.2 mm for the outer member 2 of the previous versions. In addition, the first portion 19 is provided with a convex outer surface 19a, or bulge, as most clearly shown in Figure 20, the function of which will be 5 described below. The diameter of the third portions 21 of the cartridges 1 are however the same resulting in the area of the shoulder 32 being greater in this, the third version of the cartridge 1. Typically the volume of the cartridge 1 when assembled is 32.5 ml  $\pm 20\%$ .

10 The number and positioning of the slots in the lower end of the annular wall 13 is also different. Between 3 and 5 slots are provided. In the embodiment as shown in Figure 23, four slots 36 are provided equi-spaced around the circumference of the manifold 16. The slots 36 are slightly 15 wider than in the previous versions of the cartridge 1 being between 0.35 and 0.45 mm, preferably 0.4 mm wide.

In other respects the outer members 2 of the cartridges 1 are the same.

20 The construction of the cylindrical funnel 40 of the inner member 3 is the same as in the first version of cartridge 1 with an outer tube 42, discharge spout 45, annular flange 47 and support webs 49 being provided. The only difference is that the discharge spout 45 is shaped 25 with an upper frusto-conical section 92 and a lower cylindrical section 93.

In contrast to the previous versions and as shown in Figures 24 to 28, the annular frame 41 is replaced by a skirt portion 80 which surrounds the cylindrical funnel 40 and is joined thereto by means of eight radial struts 87 30 which adjoin the cylindrical funnel 40 at or near the annular flange 47. A cylindrical extension 81 of the skirt

portion 80 extends upwardly from the struts 87 to define a chamber 90 with an open upper face. An upper rim 91 of the cylindrical extension 81 has an in-turned profile as shown in Figure 26. An annular wall 82 of the skirt portion 80 5 extends downwardly from the struts 87 to define an annular channel 86 between the skirt portion 80 and the outer tube 42.

The annular wall 82 comprises at a lower end an exterior flange 83 which lies perpendicular to the major 10 axis X. A rim 84 depends downwardly from a lower surface of the flange 83 and contains five apertures 85 which are circumferentially equi-spaced around the rim 84. Thus, the rim 84 is provided with a castellated lower profile.

Apertures 89 are provided between the struts 87 15 allowing communication between the chamber 90 and the annular channel 86.

The assembly procedure for the third version of cartridge 1 is similar to the assembly of the first version but with certain differences. The outer member 2 and inner 20 member 3 are push-fitted together as shown in Figure 29 and retained by means of a snap-fit arrangement rather than welded together. On joining the two members the inwardly directed cylindrical extension 18 is received inside the upper cylindrical extension 81 of the skirt portion 80. The 25 inner member 3 is retained in the outer member 2 by frictional interengagement of the convex outer surface 19a of the first portion 19 of the cylindrical extension 18 with the in-turned rim 91 of the upper cylindrical extension 81. With the inner member 3 located in the outer member 2 a 30 mixing chamber 134 is defined located exterior to the skirt portion 80. The mixing chamber 134 contains the beverage

ingredients 200 prior to dispensation. It should be noted that the four inlets 36 and the five apertures 85 are staggered circumferentially with respect to one another. The radial location of the two parts relative to each other need 5 not be determined or fixed during assembly since the use of four inlets 36 and five apertures 85 ensures that misalignment occurs between the inlets and apertures whatever the relative rotational positioning of the components.

10 The one or more beverage ingredients are packed into the mixing chamber 134 of the cartridge. The density of packing of the beverage ingredients in the mixing chamber 134 can be varied as desired.

15 The laminate 5 is then affixed to the outer member 2 and inner member 3 in the same manner as described above in the previous versions.

20 In use, water enters the mixing chamber 134 through the four slots 36 in the same manner as previous versions of the cartridge. The water is forced radially inwardly through the mixing chamber and mixes with the beverage ingredients contained therein. The product is dissolved or mixed in the water and forms the beverage in the mixing chamber 134 and is then driven through the apertures 85 into the annular channel 86 by back pressure of beverage and water in the 25 mixing chamber 134. The circumferential staggering of the four inlet slots 36 and the five apertures 85 ensures that jets of water are not able to pass radially directly from the inlet slots 36 to the apertures 85 without first circulating within the mixing chamber 134. In this way the 30 degree and consistency of dissolution or mixing of the product is significantly increased. The beverage is forced

upwardly in the annular channel 86, through the apertures 89 between the struts 87 and into the chamber 90. The beverage passes from chamber 90 through the inlets 45 between the support webs 49 into the discharge spout 43 and towards the 5 outlet 44 where the beverage is discharged into a receptacle such as a cup. The cartridge finds particular application with beverage ingredients in the form of viscous liquids or gels. In one application a liquid chocolate ingredient is contained in the cartridge 1 with a viscosity of between 10 1700 and 3900mPa at ambient temperature and between 5000 and 10000mPa at 0°C and a refractive solids of 67 Brix ±3. In another application liquid coffee is contained in the cartridge 1 with a viscosity of between 70 and 2000mPa at ambient and between 80 and 5000mPa at 0°C where the coffee 15 has a total solids level of between 40 and 70%. The liquid coffee ingredient may contain between 0.1 and 2.0% by weight sodium bicarbonate, preferably between 0.5 and 1.0% by weight. The sodium bicarbonate acts to maintain the pH level of the coffee at or below 4.8 enabling a shelf-life for 20 coffee-filled cartridges of up to 12 months.

A fourth version of cartridge 1 is shown in Figures 30 to 34. The fourth version of the cartridge 1 is particularly designed for use in dispensing liquid products such as concentrated liquid milk. Many of the features of the fourth 25 version of the cartridge 1 are the same as in the previous versions and like numerals have been used to reference like features. In the following description the differences between the fourth and previous versions will be discussed. Common features which function in the same manner will not 30 be discussed in detail.

The outer member 2 is the same as in the third version of cartridge 1 and as shown in Figures 19 to 23.

The cylindrical funnel 40 of the inner member 3 is similar to that shown in the second version of cartridge 1 but with certain differences. As shown in Figure 30 the discharge spout 43 is shaped with an upper frusto-conical section 106 and a lower cylindrical section 107. Three axial ribs 105 are provided on the inner surface of the discharge spout 43 to direct the dispensed beverage downwards towards the outlet 44 and prevent the discharged beverage from spinning within the spout. Consequently, the ribs 105 act as baffles. As in the second version of cartridge 1, an air inlet 71 is provided through the annular flange 47. However, the chute 75 beneath the air inlet 71 is more elongated than in the second version.

A skirt portion 80 is provided similar to that shown in the third version of the cartridge 1 described above.

Between 5 and 12 apertures 85 are provided in the rim 84. Typically ten apertures are provided rather than the five provided in the third version of cartridge 1.

An annular bowl 100 is provided extending from and integral with the flange 83 of the skirt portion 80. The annular bowl 100 comprises a flared body 101 with an open upper mouth 104 which is directed upwards. Four feed apertures 103 shown in Figures 30 and 31 are located in the body 101 at or near the lower end of the bowl 100 where it joins the skirt portion 80. Preferably, the feed apertures are equi-spaced around the circumference of the bowl 100.

The laminate 5 is of the type described above in the previous embodiments.

The assembly procedure for the fourth version of cartridge 1 is the same as that for the third version.

Operation of the fourth version of cartridge is similar to that of the third version. The water enters the 5 cartridge 1 and the mixing chamber 134 in the same manner as before. There the water mixes with and dilutes the liquid product which is then forced out below the bowl 100 and through the apertures 85 towards the outlet 44 as described above. The proportion of the liquid product initially 10 contained within the annular bowl 100 as shown in Figure 34 is not subject to immediate dilution by the water entering the mixing chamber 134. Rather, the diluted liquid product in the lower part of the mixing chamber 134 will tend to exit through apertures 85 rather than be forced up and into 15 the annular bowl 100 through upper mouth 104. Consequently, the liquid product in the annular bowl 100 will remain relatively concentrated during the initial stages of the operating cycle compared to the product in the lower part of the mixing chamber 134. The liquid product in the annular 20 bowl 100 drips through the feed apertures 103 under gravity into the stream of product exiting the mixing chamber 134 through the apertures 85 and below the bowl 100. The annular bowl 100 acts to even out the concentration of the diluted liquid product entering the cylindrical funnel 40 by 25 holding back a proportion of the concentrated liquid product and releasing it into the exiting liquid stream flow path steadily throughout the operating cycle as illustrated in Figure 46a where the concentration of the milk measured as a percentage of the total solids present is shown during an 30 operating cycle of approximately 15 seconds. Line a illustrates the concentration profile with the bowl 100

whilst line b illustrates a cartridge without the bowl 100. As can be seen the concentration profile with the cup 100 is more even during the operating cycle and there is no immediate large drop in concentration as occurs without the bowl 100. The initial concentration of the milk is typically 30-35% SS and at the end of the cycle 10% SS. This results in a dilution ratio of around 3 to 1, although dilution ratios of between 1 to 1 and 6 to 1 are possible with the present invention. For other liquid beverage ingredients the concentrations may vary. For example for liquid chocolate the initial concentration is approximately 67% SS and at the end of the cycle 12-15% SS. This results in a dilution ratio (ratio of aqueous medium to beverage ingredient in dispensed beverage) of around 5 to 1, although dilution ratios of between 2 to 1 and 10 to 1 are possible with the present invention. For liquid coffee the initial concentration is between 40-67% and the concentration at the end of dispense 1-2% SS. This results in a dilution ratio of between 20 to 1 and 70 to 1, although dilution ratios of between 10 to 1 and 100 to 1 are possible with the present invention.

From the annular channel 86 the beverage is forced under pressure through the aperture 128 by the back pressure of beverage collecting in the filtration chamber 134 and chamber 90. The beverage is thus forced through aperture 128 as a jet and into an expansion chamber formed by the upper end of the discharge spout 43. As shown in Figure 34, the jet of beverage passes directly over the air inlet 71. As the beverage enters the discharge spout 43 the pressure of the beverage jet drops. As a result air is entrained into the beverage stream in the form of a multitude of small air bubbles as the air is drawn up through the air inlet 71.

The jet of beverage issuing from the aperture 128 is funnelled downwards to the outlet 44 where the beverage is discharged into a receptacle such as a cup where the air bubbles form the desired frothy appearance.

5        Advantageously, the inner member 3, outer member 2, laminate 5 and filter 4 can all be readily sterilised due to the components being separable and not individually comprising tortuous passageways or narrow crevices. Rather, it is only after conjoining the components, after  
10 sterilisation, that the necessary passageways are formed. This is particularly important where the beverage ingredient is a dairy-based product such as liquid milk concentrate.

The fourth embodiment of beverage cartridge is particularly advantageous for dispensing a concentrated  
15 dairy-based liquid product such as liquid milk. Previously, powdered milk products have been provided in the form of sachets for adding to a pre-prepared beverage. However, for a cappuccino-style beverage it is necessary to foam the milk. This has been achieved previously by passing steam  
20 through a liquid milk product. However this necessitates the provision of a steam supply which increases the cost and complexity of the machine used to dispense the beverage. The use of steam also increases the risk of injury during operation of the cartridge. Accordingly the present  
25 invention provides for a beverage cartridge having a concentrated dairy-based liquid product therein. It has been found that by concentrating the milk product a greater amount of foam can be produced for a particular volume of milk when compared to fresh or UHT milk. This reduces the  
30 size required for the milk cartridge. Fresh semi-skimmed milk contains approximately 1.6% fat and 10% total solids.

The concentrated liquid milk preparations of the present invention contain between 0.1 and 12% fat and 25 to 40% total solids. In a typical example, the preparation contains 4% fat and 30% total solids. The concentrated milk 5 preparations are suitable for foaming using a low pressure preparation machine as will be described below. In particular, foaming of the milk is achieved at pressures below 2 bar, preferably approximately 1.5 bar using the cartridge of the fourth embodiment described above.

10 The foaming of the concentrated milk is particularly advantageous for beverages such as cappuccinos and milk shakes. Preferably the passing of the milk through the aperture 128 and over the air inlet 71 and the optional use of the bowl 100 enables foaming levels of greater than 40%, 15 preferably greater than 70% for milk. For liquid chocolate foaming levels of greater than 70% are possible. For liquid coffee foaming levels of greater than 70% are possible. The foamability level is measured as the ratio of the volume of the foam produced to the volume of liquid beverage 20 ingredient dispensed. For example, where 138.3ml of beverage is dispensed, of which 58.3ml is foam the foamability is measured as  $[58.3/(138.3-58.3)]*100 = 72.9\%$ . The foamability of the milk (and other liquid ingredients) is enhanced by the provision of the bowl 100 as can be seen in Figure 46b. 25 The foamability of the milk dispensed with the bowl 100 present (line a) is greater than that of milk dispensed without the bowl present (line b). This is because the foamability of the milk is positively correlated to the concentration of the milk and as shown in Figure 46a the 30 bowl 100 maintains a higher concentration of the milk a larger part of the operating cycle. It is also known that

foamability of the milk is positively correlated to temperature of the aqueous medium as shown in Figure 46c. Thus the bowl 100 is advantageous since more of the milk remains in the cartridge until near the end of the operating 5 cycle when the aqueous medium is at its hottest. This again improves foamability.

The cartridge of the fourth embodiment is also advantageous in dispensing liquid coffee products.

It has been found that the embodiments of beverage 10 cartridge of the present invention advantageously provide an improved consistency of the brewed beverage when compared to prior art cartridges. Reference is made to Table 1 below which shows the results of brew yields for twenty samples each of cartridges A and B containing roast and ground 15 coffee. Cartridge A is a beverage cartridge according to the first embodiment of the present invention. Cartridge B is a prior art beverage cartridge as described in the applicant's document WO01/58786. The refractive index of the brewed beverage is measured in Brix units and converted to a 20 percentage of soluble solids (%SS) using standard tables and formulae. In the examples below:

$$\%SS = 0.7774 * (\text{Brix value}) + 0.0569.$$

25        
$$\% \text{ Yield} = (\%SS * \text{Brew Volume (g)}) / (100 * \text{Coffee Weight (g)})$$

Table 1

**CARTRIDGE A**

Sample	Brew Volume (g)	Coffee Weight (g)	Brix	% SS (*)	% Yield
1	105.6	6.5	1.58	1.29	20.88

2	104.24	6.5	1.64	1.33	21.36
3	100.95	6.5	1.67	1.36	21.05
4	102.23	6.5	1.71	1.39	21.80
5	100.49	6.5	1.73	1.40	21.67
6	107.54	6.5	1.59	1.29	21.39
7	102.70	6.5	1.67	1.36	21.41
8	97.77	6.5	1.86	1.50	22.61
9	97.82	6.5	1.7	1.38	20.75
10	97.83	6.5	1.67	1.36	20.40
11	97.6	6.5	1.78	1.44	21.63
12	106.64	6.5	1.61	1.31	21.47
13	99.26	6.5	1.54	1.25	19.15
14	97.29	6.5	1.59	1.29	19.35
15	101.54	6.5	1.51	1.23	19.23
16	104.23	6.5	1.61	1.31	20.98
17	97.5	6.5	1.73	1.40	21.03
18	100.83	6.5	1.68	1.36	21.14
19	101.67	6.5	1.67	1.36	21.20
20	101.32	6.5	1.68	1.36	21.24
AVERAGE					20.99

**CARTRIDGE B**

Sample	Brew Volume (g)	Coffee Weight (g)	Brix	% SS (*)	% Yield
1	100.65	6.5	1.87	1.511	23.39
2	95.85	6.5	1.86	1.503	22.16
3	98.4	6.5	1.8	1.456	22.04
4	92.43	6.5	2.3	1.845	26.23
5	100.26	6.5	1.72	1.394	21.50
6	98.05	6.5	2.05	1.651	24.90
7	99.49	6.5	1.96	1.581	24.19
8	95.62	6.5	2.3	1.845	27.14
9	94.28	6.5	2.17	1.744	25.29
10	96.13	6.5	1.72	1.394	20.62
11	96.86	6.5	1.81	1.464	21.82
12	94.03	6.5	2.2	1.767	25.56
13	96.28	6.5	1.78	1.441	21.34
14	95.85	6.5	1.95	1.573	23.19
15	95.36	6.5	1.88	1.518	22.28
16	92.73	6.5	1.89	1.526	21.77
17	88	6.5	1.59	1.293	17.50
18	93.5	6.5	2.08	1.674	24.08
19	100.88	6.5	1.75	1.417	22.00

20	84.77	6.5	2.37	1.899	24.77
AVERAGE			23.09		

Performing a t-test statistical analysis on the above data gives the following results:

5

Table 2

t-Test: Two-Sample Assuming Equal Variances

	% Yield (Cartridge A)	% Yield (Cartridge B)
Mean	20.99	23.09
Variance	0.77	5.04
Observations	20	20
Pooled Variance	2.90	
Hypothesized Mean Difference	0	
df	38	
t Stat	-3.90	
P(T<=t) one-tail	0.000188	
t Critical one-tail	1.686	
P(T<=t) two-tail	0.000376	
t Critical two-tail	2.0244	
Standard Deviation	0.876	2.245

The analysis shows that the consistency of % yield, which equates to brew strength, for the cartridges of the present invention is significantly better (at a 95% confidence level) than the prior art cartridges, with a standard deviation of 0.88% compared to 2.24%. This means that beverages brewed with the cartridges of the present invention have a more repeatable and uniform strength. This is preferred by consumers who like their drinks to taste the same time after time and do not want arbitrary changes in brew strength.

The materials of the cartridges described above may be provided with a barrier coating to improve their resistance

to oxygen and/or moisture and/or other contaminant ingress. The barrier coating may also improve the resistance to leakage of the beverage ingredients from within the cartridges and/or reduce the degree of leaching of 5 extractibles from the cartridge materials which might adversely affect the beverage ingredients. The barrier coating may be of a material selected from the group of PET, Polyamide, EVOH, PVDC or a metallised material. The barrier coating may be applied by a number of mechanisms including 10 but not limited to vapour deposition, vacuum deposition, plasma coating, co-extrusion, in-mould labelling and two/multi-stage moulding.

A beverage preparation machine 201 according to the present invention for use with the above described beverage 15 cartridges is shown in Figures 35 to 45. The beverage preparation machine 201 generally comprises a housing 210 containing a water tank 220, a water heater 225, a water pump 230, an air compressor 235, a control processor, a user interface 240 and a cartridge head 250. The cartridge head 20 250 in turn generally comprises a cartridge holder 251 for holding, in use, the beverage cartridge 1, cartridge recognition means 252 and inlet and outlet piercers 253, 254 for forming, in use, the inlet 121 and the outlet 122 in the beverage cartridge 1.

25 The housing 210 contains and holds in position the other components of the machine 201. The housing 210 preferably made in whole or in part from a robust plastics material such as ABS. Alternatively, the housing 210 can be made in whole or in part from a metallic material such as 30 stainless steel or aluminium. The housing 210 is preferably comprises a clam-shell design having a front half 211 and a

rear half 212 which allow access during assembly for fitting of the machine 201 components and can afterwards be joined together to define an interior 213 of the housing 210. The rear half 212 provides a recess 214 for the attachment of 5 the water tank 220. The housing 210 is formed with means, such as detents, abutments, bosses and threaded portions, for retaining the components of the machine 201 in position without the need for a separate chassis. This reduces the overall cost and weight of the machine 201. A base 215 of 10 the housing 210 is preferably provided with feet for standing the machine thereon in a stable manner. Alternatively, the base 215 itself may have a shape forming a stable support.

The front half 211 of the housing 210 comprises a 15 dispense station 270 where dispensation of the beverage takes place. The dispense station 270 comprises a receptacle stand 271 having a hollow interior forming a drip tray 272. An upper surface 273 of the receptacle stand is provided with a grill 274 on which the receptacle is 20 positioned. The drip tray 272 is removable from the housing 210 to ease emptying of the collected water. A recess 275 is formed in the front half of the housing 210 above the receptacle stand 271 to accommodate the dimensions of the receptacle.

25 The cartridge head 250 is located towards the top of the housing 210 above the receptacle stand as shown in Figures 35 and 36. Preferably, the height of the grill 274 relative to the cartridge head 250 can be adjusted to accommodate different sizes of receptacle. It is preferred 30 that the receptacle is as close to the cartridge head 250 as possible, whilst still allowing the receptacle to be

inserted and withdrawn from the dispense station 270, so as to minimise the height that the dispensed beverage has to descend before contacting the receptacle. This acts to minimise spraying and splashing of the beverage and minimise 5 loss of entrained air bubbles where these are present. Preferably receptacles of between 70mm and 110 mm in height can be inserted between the grill 274 and cartridge head 250.

10 The machine user interface 240 is located on the front of the housing 210 and comprises a start/stop button 241, and a plurality of status indicators 243-246.

15 The status indicators 243-246 preferably include a light emitting diode (LED) 243 to indicate readiness of the machine 201, a LED 244 to indicate if an error has occurred in the machine 201 operation, and one or more LEDs 245-256 to indicate whether the machine 201 is operating in manual or automatic modes. The LEDs 243-246 may be controlled to illuminate at a constant intensity, to flash intermittently, or both depending on the status of the machine 201. The LEDs 20 243-246 may have a variety of colours including green, red and yellow.

The start/stop button 241 controls commencement of the operating cycle and is a manually operated push-button, switch or similar.

25 A volume adjustment control may be provided to allow a user of the machine 201 to manually adjust the volume of the delivered beverage without altering the other operating characteristics. Preferably the volume adjustment control allows an adjustment in volume of plus or minus 20%. The 30 volume adjustment control may be a rotary knob, a linear slider, a digital readout with increment and decrement

buttons, or similar. More typically, volume is controlled by a user operating the start/stop button 241.

A manual power switch (not shown) may be provided on the machine 201. Alternatively, power supply can be  
5 controlled simply by insertion or removal or the power supply plug from the mains power supply.

The water tank 220 is located to the rear of the housing 210 and is connected to the rear half 212 of the housing 210. The water tank 220 comprises a generally  
10 cylindrical body 221 which may be right circular or a frustum as desired for aesthetic reasons. The tank comprises an inlet for filling the tank with water which is closed off in use by a manually removable lid 222. An outlet is provided towards a lower end of the tank which  
15 communicates with the water pump 230. The water tank 220 may be made from a transparent or translucent material to allow a consumer to view the quantity of water remaining in the tank. Alternatively, the water tank 220 may be made from an opaque material but have provided a viewing window therein.  
20 In addition, or in place of the above, the water tank 220 may be provided with a low level sensor which prevents operation of the water pump 230 and optionally triggers a warning indicator, such as an LED, when the water level in the tank descends to a preselected level. The water tank 220  
25 preferably has an internal capacity of approximately 1.5 litres.

The water pump 230 is operatively connected between the water tank 220 and the water heater 225 as shown schematically in Figure 43 and is controlled by the control  
30 processor. The pump provides a maximum flow rate of 900 ml/min of water at a maximum pressure of 2.5 bar.

Preferably, in normal use, the pressure will be limited to 2 bar. The flow rate of water through the machine 201 can be controlled by the control processor to be a percentage of the maximum flow rate of the pump by cycle chopping the 5 electrical supply to the pump. Preferably the pump can be driven at any of 10%, 20%, 30%, 40%, 50%, 60%, 70%, 80%, 90% or 100% of the maximum rated flow rate. The accuracy of the volume of water pumped is preferably + or - 5% leading to a + or - 5% accuracy in the final volume of the dispensed 10 beverage. A suitable pump is the Evolution EP8 pump produced by Ulka S.r.l. (Pavia, Italy). A volumetric flow sensor (not shown) is preferably provided in the flow line either upstream or downstream of the water pump 230. Preferably, the volumetric flow sensor is a rotary sensor.

15 The water heater 225 is located in the interior of the housing 210. The heater 225 has a power rating of 1550 W and is able to heat water received from the water pump 230 from a starting temperature of approximately 20 °C to an operating temperature of around 85 °C in under 1 minute. 20 Preferably the dwell time between the end of one operating cycle and the heater 225 being able to commence a subsequent operating cycle is less than 10 seconds. The heater maintains the selected temperature to within + or - 2 °C during the operating cycle. As discussed below, the water 25 for the operating cycle may be delivered to the cartridge head 250 at 83 °C or 93 °C. The heater 225 is able to quickly adjust the delivery temperature to either 83 °C or 93 °C from a nominal water temperature of 85 °C. The heater 225 comprises an over-temperature cut-off which shuts off 30 the heater if the temperature exceeds 98 °C. Water output from the heater 225 is fed to the cartridge head 250 and

cartridge 1 by means of a three-way valve. If the pressure of the water flow is acceptable the water is passed to the cartridge 1. If the pressure is below or above predetermined limits then the water is diverted by means of the three-way 5 valve into the drip tray recovery receptacle 270.

The air compressor 235 is operatively connected to the cartridge head 250 by means of a one-way valve and controlled by the control processor. The air compressor 235 provides a maximum flow rate of air of 500 ml/min at 1.0 10 bar. In use a working volume of 35 ml is pressurised to 2.0 bar. Preferably, the air compressor 235 can produce two flow rates: a fast (or maximum) flow rate and a slow flow rate.

The control processor of the beverage preparation machine 201 comprises a processing module and a memory. The 15 control processor is operatively connected to, and controls operation of, the water heater 225, water pump 230, air compressor 235 and user interface 240.

The memory of the control processor includes one or more variables for one or more operational parameters for 20 the beverage preparation machine 201. In the illustrated embodiment the operational parameters are the temperature of the water passed through the beverage cartridge 1 during the operating stage, the speed of charging the beverage cartridge 1, the presence or otherwise of a soak step, the 25 total dispensed volume of the beverage, the flow rate of the water during the discharge stage, and the flow rate and period of the purge stage.

The variables for the operational parameters are stored in the memory. The cartridge 1 comprises a code provided on 30 or in the cartridge 1 representing the operational parameters required for optimal dispensation of the beverage

in that cartridge 1. The code is in binary format and comprises a plurality of data bits corresponding to the variables stored in the control processor memory. Table 3 illustrates how 13 bits of data can be used to represent the 5 necessary variables for the operational parameters described above.

Table 3

Bit	Parameter	Description
0 & 1	Water temperature	00 = cold 01 = warm 10 = 83 °C 11 = 93 °C
2 & 3	Cartridge charge	00 = fast charge with soak 01 = fast charge without soak 10 = slow charge with soak 11 = slow charge without soak
4, 5, 6 & 7	Beverage volume	0000 = 50 ml 0001 = 60 ml 0010 = 70 ml 0011 = 80 ml 0100 = 90 ml 0101 = 100 ml 0110 = 110 ml 0111 = 130 ml 1000 = 150 ml 1001 = 170 ml 1010 = 190 ml 1011 = 210 ml 1100 = 230 ml 1101 = 250 ml 1110 = 275 ml 1111 = 300 ml
8, 9 & 10	Flow rate	000 = 30% 001 = 40%

		010 = 50% 011 = 60% 100 = 70% 101 = 80% 110 = 90% 111 = 100%
11 &12	Purge	00 = slow flow/short period 01 = slow flow/long period 10 = fast flow/short period 11 = fast flow/long period

The code on or in the cartridge 1 will normally comprises one or more extra data bits for error checking. In one example a 16 bit code is provided. For example, using 5 the variables listed in Table 3, a cartridge 1 bearing the code "1000100011110" would have the following operational parameters:

10           Water temperature of 83 °C  
00           Fast charge with soak  
10        1000      Dispensed drink volume of 150ml  
111       Flow rate equals 100%  
10        Fast air flow purge/short period.

Thus, unlike in previous beverage preparation machines, the memory of the control processor does not store 15 operational instructions for beverage cartridges based on the cartridge type, i.e. instructions for a coffee cartridge, instructions for a chocolate cartridge, instructions for a tea cartridge etc. Instead the memory of the control processor stores variables for adjusting the 20 individual operational parameters of the operating cycle. This has a number of advantages. Firstly, a greater degree of control of the dispensation cycle can be exercised. For example, slightly different operational parameters can be

used for different grades or blends of coffee rather than using the same parameters for all types of coffee. Prior coding solutions relying on storing instructions by cartridge type rather than by individual parameters are

5 unsuited to such subtle differences in operating cycles for similar beverage types because they quickly consume the available storage space in the coding medium and control processor. Secondly, the coding method of the present invention allows for new beverage cartridge types to be used

10 in pre-existing beverage preparation machines even where the operational parameters for the operating cycle for the new beverage cartridge 1 are only decided upon after sale of the beverage preparation machine 201. This is because the control processor of the beverage preparation machine 201

15 does not need to recognise that the beverage is of a new type. Rather the operational parameters of the operating cycle are set without direct reference to the beverage type. Hence the coding method of the present invention provides excellent backward compatibility of the beverage preparation

20 machines for new beverage types. In contrast, with prior machines, the manufacturer is restricted to dispensing a new beverage type using one of the pre-existing dispensation cycles as determined by the in-market machines.

The cartridge head 250 is shown in Figures 39 to 42.

25 The cartridge holder 251 of the cartridge head 250 comprises a fixed lower part 255, a rotatable upper part 256 and a pivotable cartridge mount 257 positioned inbetween the fixed lower part 255 and the rotatable upper part 256. The upper part 256, lower part 255 and cartridge mount 257 are rotated

30 about a common hinge axis 258. Figures 39 to 42 show the

cartridge holder 251 with some components of the machine 201 omitted for clarity.

The rotatable upper part 256 and pivotable cartridge mount 257 are moved relative to the fixed lower part 255 by 5 means of a clamping mechanism 280. The clamping mechanism 280 comprises a clamping lever having first and second members or parts 281 and 282. The first part 281 of the clamping lever comprises a U-shaped arm which is pivotably mounted to the upper part 256 at two first pivot points 283, 10 one on each side of the cartridge holder 251.

The second part of the clamping lever comprises two over-centre arms 282, one on each side of the cartridge holder 251 which are each pivotably mounted to the upper part 256 at a second pivot point 285 located on the hinge 15 axis 258 coupling the upper part 256 to the fixed lower part 255. Each over-centre arm 282 is a reciprocal member comprising a cylinder 282a, a stem 282b and a resilient sleeve 282c. The cylinder 282a has an internal bore and is rotatably mounted at one end at the hinge axis 258. A first 20 end of the stem 282b is slidably received in the bore of the cylinder 282a. The opposite end of the stem 282b is rotatably mounted to the U-shaped arm 281 at a third pivot point 286. The third pivot points 286 are unconnected to, and freely moveable relative to, the upper part 256 and 25 lower part 255. The resilient sleeve 282c is mounted externally on the stem 282b and extends, in use, between abutment surfaces on the cylinder 282a and stem 282b. The resilient sleeve 282c accommodates shortening of the over-centre arm 282 but biases the over-centre arm 282 into an 30 extended configuration. Movement of the third pivot points 286 towards and away from the hinge axis 258 is thus

possible by relative movement of the stems 282b in the cylinders 282a. The resilient sleeves 282c are preferably formed from silicone.

The U-shaped arm 281 extends around the front of the 5 cartridge holder 251 and comprises two downwardly dependant hook members 287, one on each side of the cartridge holder 251, each comprising a cam surface 288 facing the hinge axis 258. The fixed lower part 255 of the cartridge holder 251 is provided with two bosses 259, or detents, located one on 10 each side of the lower part 255 at or near a front edge 260 thereof aligned generally with the hook members 287.

As shown in Figure 39, the U-shaped arm 281 may be formed from a one piece plastics moulding comprising an ergonomic hand grip and the hook members 287 integral to the 15 arm.

The cartridge mount 257 is rotatably mounted between the upper and lower parts 255, 256 of the cartridge holder 251. The mount 257 is provided with a substantially circular recess 290 which receives in use the beverage cartridge 1. 20 The recess 290 includes an irregularity 291 for accommodating the handle portion 24 of the beverage cartridge 1 which also acts to prevent rotation of the beverage cartridge 1 in the cartridge holder 251. The cartridge mount 257 is sprung relative to the fixed lower 25 part 255 such that in the open position, as shown in Figure 41, the cartridge mount 257 is biased out of contact with the fixed lower part 255 so that the cartridge mount 257 is moved out of contact with the outlet and inlet piercer members 254, 253. The cartridge mount 257 is provided with 30 an aperture 292 for receiving therethrough the inlet and outlet piercers 253, 254 and a head 300 of the cartridge

recognition means 252 when the cartridge mount 257 is moved into the closed position.

The upper part 255 comprises a generally circular body 310 housing a circular viewing window 312 through which a consumer can view the beverage cartridge 1 during an operating cycle and also visually confirm whether a cartridge 1 is loaded in the machine 201. The viewing window 312 is cup-shaped having a downwardly directed rim 311 which engages and grips the flange 35 of the beverage cartridge 1 against the lower part 256 when the cartridge holder 251 is closed. At the same time the window 312 contacts the closed top 11 of the cartridge 1. A wave spring (not shown) is positioned between the viewing window 312 and the circular body 310 to enable the viewing window 312 to move axially relative to the circular body 310 by a small degree. The pressure exerted by the rim 311 on the flange 35 and by the window 312 on the closed top 11 ensures a fluid tight seal between the cartridge 1 and the cartridge holder 251.

The lower part 255 comprises the inlet and outlet piercers 253, 254 and the head 300 of the cartridge recognition means 252. The inlet piercer 253 comprises a hollow needle-like tube 260 having a sharpened end 261 for perforating the laminate 5 of the beverage cartridge 1 in use. The inlet piercer 253 is in fluid communication with a water conduit 262 as shown in Figure 42 which passes through the lower part 255 and is connected to an outlet conduit 263 of the water heater 225. The outlet piercer 254 is similar in type to the outlet piercer described in the applicant's European patents EP 0 389 141 and EP 0 334 572 and comprises an open ended cylinder 264 of circular or D-shaped cross-section having dimensions larger than the discharge spout

43. An arcuate portion 265 of the upper end of the outlet piercer 254 is serrated to pierce and eventually cut the laminate of the beverage cartridge 1. The remainder of the upper end is cut back longitudinally of the cylinder at 5 least to the base of the teeth 266 of the serrated portion to fold or pull the cut laminate 5 away from the outlet aperture before the beverage is dispensed therethrough. The outlet piercer 254 pierces the laminate 5 externally of the discharge spout 43 and when the cartridge mount 257 is in 10 the closed position, rests in the annulus between the discharge spout 43 and the outer wall 42 of the discharge funnel 40. The outlet piercer 254 folds back the cut laminate 105 into the annulus. Thereby both the outlet piercer 254 and the cut laminate 105 are held out of the way 15 of the discharged beverage.

The outlet piercer 254 is surrounded by a ledge 254a which is raised relative to its surroundings by 0.5mm.

Advantageously, the outlet piercer 254 is removable from the lower part 255 to enable it to be thoroughly 20 cleaned, for example, in a dishwasher. The removable outlet piercer 254 is received in a recess 267 in the lower part 255 where it is seated. The inlet piercer 253 and/or the outlet piercer 254 may be made of a metal, such as stainless steel, or from a plastics material. Advantageously, the use 25 of plastic cutting elements is enabled by use of a laminate 5 which is able to be punctured and cut by a non-metallic material. Consequently, the piercers 253, 254 can be made less sharp which lowers the risk of injury to the consumer. In addition, plastic piercing elements are not prone to 30 rust. Preferably, the inlet piercer 253 and the outlet

piercer 24 are formed as a single, integral unit which is removable from the lower part 255.

In use, the upper part 256 of the cartridge holder 251 is movable from an open position in which it is orientated vertically or towards the vertical as shown in Figure 36, to a closed position in which it is orientated substantially horizontally and in interengagement with the fixed lower part 255 and cartridge mount 257. The upper part 256 is moved from the open to the closed positions by operation of the clamping lever. To close the upper part 256 a user takes hold of the clamping lever by the U-shaped arm 281 and pulls downwards. Consequently, the upper part 256 rotates which first brings the rim 311 of the viewing window 312 into contact with the flange 35 of the beverage cartridge 1 in the cartridge mount 257 and the window 312 itself into contact with the closed top 11 of the cartridge 1. Continued rotation of the upper part 256 rotates the upper part 256 and cartridge mount 257 down into contact with the lower part 255. Further rotation of the U-shaped arm 281 causes the U-shaped arm 281 to rotate relative to the upper part 256 and the lower part 255 resulting in the hook members 287 of the upper part 256 engaging the bosses 259 of the lower part 255 with the cam surface 288 riding over the bosses 259. During this last stage of rotation the cartridge 1 is compressed between the cartridge mount 257 and the viewing window 312. As a result, the viewing window 312 is moved axially relative to the circular body 310 of the upper part 256 against the bias of the wave spring. This movement allows for a take up of tolerances in the beverage cartridge 1 and beverage preparation machine and ensures that the amount of compressive force applied to the cartridge is kept

within an acceptable range. The clamping force of the mechanism as moderated by the action of the wave spring ensures a clamping pressure on the cartridge of between 130 and 280N. Preferably the force is approximately 200N. A 5 force less than about 130N does not provide an adequate seal, whilst a force greater than about 280N leads to plastic failure of the components of the cartridge 1. During closure of the cartridge head the laminate 5 of the cartridge 1 is tensioned as it is brought into contact with 10 the ledge 254a surrounding the outlet piercer 254 which causes the laminate 5 to flex out of plane as the distal end of the outer tube 42 of the cylindrical funnel is moved upwardly by 0.5mm relative to the flange 35. This movement also ensures that the great majority of the compressive 15 force applied to the cartridge acts through the central region of the cartridge 1 through the load-bearing inner member 3. In the closed position the cartridge 1 is thus clamped around the flange 35 by means of the rim 311 of the viewing window 312 and firmly clamped between the closed top 20 11 of the cartridge and the outer tube 42 of the inner member 3 by contact with the viewing window 312 and the ledge 254a. These clamping forces help prevent failure of the cartridge 1 during pressurisation and also ensure that the inner member 3 and outer member 2 are fully seated 25 relative to one another and thus that all internal passageways and apertures remain at their intended dimensions even during internal pressurisation.

An imaginary datum line can be drawn between the first and second pivot points 283, 285 of the cartridge holder 30 251. As can be seen in Figure 41, in the open position the third pivot points 286 are located on the side of the datum

line nearest the fixed lower part 255. As the upper part 256 reaches the closed position, the third pivot points 286 of the clamping lever pass through the datum line joining the first and second pivot points 283, 285 to the opposite side 5 of the line, furthest from the fixed lower part 255. Consequently, the U-shaped arm 281 'snaps through' from a first stable position to a second stable position. The snap through action is accommodated by shortening of the over-centre arms 282 and consequential compression of the 10 resilient sleeves 282c. Once the third pivot points 286 are past the imaginary datum line then recovery of the resilient sleeves 282c acts to continue the motion of the third pivot points 286 away from the imaginary datum line. The clamping lever thus has a bi-stable operation in that the lever is 15 stable in the open or closed positions but unstable at the point when the third pivot points 286 lie on the imaginary datum line joining the first and second pivot points 283, 285. Thus, the snap-through action of the clamping lever provides a positive closure mechanism which leads to a 20 definite closure action wherein in the final stages of the clamping lever's rotation, the snap-through action of the U-shaped arm 281 and second arms 284 forces the hook members 287 firmly into engagement with the bosses 259. In addition, the resilient sleeves 282c provide a resistance to 25 re-opening of the upper part 256 since a minimum force is required to compress the sleeves 282c sufficiently to move the third pivot points 286 back into line with the datum line joining the first and second pivot points 283, 285. Advantageously, the interengagement of the hook members 287 30 and the bosses 259 prevents separation of the upper and lower parts other than by rotation of the clamping lever.

This is useful in preventing opening of the cartridge head 250 during operation when the cartridge head 250 is subject to internal pressurisation.

The purpose of the cartridge recognition means 252 is 5 to allow the machine 201 to recognise the type of beverage cartridge 1 that has been inserted and to adjust one or more operational parameters accordingly. In a typical embodiment, the cartridge recognition means 252 comprises an optical barcode reader which reads a printed barcode 320 provided on 10 the laminate 5 of the beverage cartridge 1 as shown in Figure 45. The barcode 320 is formed from a plurality of bars of contrasting colour. Preferably the bars are black on a white background to maximise the contrast. The barcode 320 is not required to conform to a published standard but a 15 standard format for barcodes, such as EAN-13, UPC-A, or Interleaved 2 of 5 may be used. The optical barcode reader comprises one or more LEDs 321 to illuminate the barcode 320, a focusing lens 322 to acquire an image of the barcode, a charge coupled device (CCD) 323 for producing an 20 electrical signal representative of the acquired image and support circuitry for the LEDs and CCD. The space in the lower part for accommodating the barcode reader is limited. A mirror or mirrors 324 may be used to reflect the light from the LEDs 321 to a focussing lens which is not located 25 in the lower part 255. Schematic arrangements are shown in Figures 44a and 44b. The lower part 255 comprises an aperture 326 which is the same size as the barcode 320 on the beverage cartridge 1. In use the electrical signals produced are decoded by signal processing software and the 30 results forwarded to the control processor. The software can recognise whether the read of the barcode contained errors.

The barcode 320 may be rescanned a number of times before an error message is presented to the consumer. If the machine 201 is unable to read the barcode the consumer is able to use the beverage cartridge 1 to dispense a beverage using a 5 manual mode of operation.

The cartridge head 250 also includes a cartridge sensor for detecting whether a cartridge is present in the cartridge holder 251.

The cartridge head 250 also includes a lock sensor 10 which detects whether the cartridge holder 251 is properly closed. Preferably the lock sensor comprises a micro-switch which is triggered when the cartridge holder 251 is closed and locked. Preferably the cartridge sensor and lock sensor are connected in series such that the output of both sensors 15 must be satisfactory, i.e. cartridge present and mechanism locked, before the operating cycle can be commenced.

Operation of the machine 201 comprises insertion of a beverage cartridge 1 into the cartridge head 250, carrying out an operating cycle in which the beverage is dispensed 20 and removal of the cartridge 1 from the machine.

The operational behaviour of the machine 201 is determined by software embedded in the control processor. Operation of the machine can be described in terms of 'States', wherein the machine 201 will normally exist in a 25 particular State until an event occurs to change the State, a step called a State transition.

Table 4 shows a State Transition Table which illustrates the States and State transitions for one embodiment of the beverage preparation machine 201.

Table 4

State	State Description	Temperature	Lock Sensor	Cartridge Sensor variable (OK, NOK, CLR)	Water level indicator	Water flow rate	StartStop
1	WATER HEATING	> or = 85 goto 2	Closed: [Cartridge Sensor = readpod()] Open: [Cartridge Sensor = CLR]	N/A	Low goto 10	N/A	No Action
2	WATER READY If timeout 10mins goto 9	< 85 goto 2	Closed: [Cartridge Sensor = readpod()] Open: [Cartridge Sensor = CLR]	Cartridge Sensor =OK goto 4 Cartridge Sensor =NOK goto 3	Low goto 10	N/A	No Action
3	READY TO BREW AUTO	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 2	N/A	Low goto 10	N/A	Goto 5
4	BREW IN PROGRESS AUTO [Run Brew State] goto 7	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 10	N/A	Low goto 10	No flow goto 10	Water off goto 6
5	BREW SUSPENDED	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 10	N/A	Low goto 10	N/A	Goto 5
6	READY TO BREW MANUAL	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 2	N/A	Low goto 10	N/A	[Water On] Goto 8

7	BREW IN PROGRESS MANUAL	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 10	N/A	Low goto 10	No flow goto 10	Released goto 7
8	PURGE [Water off; air on, timeout n sec then goto 9]	N/A [temperature controlled in background]	Open: [Cartridge Sensor =CLR] goto 10	N/A	No action	N/A	No Action
9	BREW DONE [air purge] [Cartridge Sensor =CLR] if timeout 10s goto 2	N/A [temperature controlled in background]	Open goto 2	N/A	Low goto 10	N/A	Goto 9
10	STANDBY	N/A [heater off]	Open: [Cartridge Sensor =CLR] goto 1 Closed: [Cartridge Sensor = readpod()]	N/A	Low goto 10	N/A	Goto 1
11	ERROR Power off/on required to clear	N/A	N/A	N/A	N/A	N/A	N/A
12	WATER LOW				Low goto 10		

The following example illustrates an operating cycle to exemplify the use of the State Transitions by the control processor.

5 It is assumed that the machine 201 is initially switched off and with no cartridge 1 inserted in the cartridge head 250. When the machine 201 is switched on the control processor is in State 1. The water heater 225 is switched on. Once the temperature reaches 85 °C the control

processor transits to State 2. If at any time during State 1 or 2 the cartridge holder 251 is closed the lock sensor will be triggered to send a signal to the control processor indicating that the cartridge holder 251 is properly closed.

5 The control processor then interrogates the cartridge sensor by sending a 'readpod' instruction. The cartridge sensor returns a signal to the control processor indicating whether a cartridge is in place in the cartridge holder 251. If no cartridge is present the control processor transits to State 10 3 where it remains in a readiness state until the cartridge holder 251 is reopened at which point the control processor transits back to State 2. If a cartridge is present in State 2 then the control processor transits to State 4 and operation is commenced automatically. During States 4 to 9 15 the water temperature is controlled in the background to remain within the required tolerance range of the desired temperature as set by the operational parameters set by the barcode on the beverage cartridge 1. Once the discharge stage of dispense is completed an air purge is commenced in 20 State 8. Once the air purge is completed the operating cycle is completed and the machine enters to standby mode in State 10. If, during operation, an error occurs then the processor transits to State 11. If a low water level is detected then the processor transits to State 12.

25 To insert the cartridge 1 the cartridge holder 251 is opened as described above to expose the cartridge mount 257. The cartridge 1 is then placed on the cartridge mount 257 received within the recess 290 such that the handle 24 of the cartridge is located in the irregularity 291. The 30 optical or magnetic barcode 320 of the cartridge 1 is orientated directly above the aperture 326 in the cartridge

mount 257. The cartridge holder 251 is then closed by operation of the clamping lever as described above. During closure the inlet and outlet piercers 253, 254 pierce the laminate 5 of the cartridge 1 to form the cartridge inlet 5 121 and outlet 122. As described above the laminate 5 cut by the outlet piercer 254 is folded up into the annulus surrounding the discharge spout 43. When closed the cartridge holder 251 grips the cartridge 1 around the rim 35 between the cartridge mount 257 and the upper part 256 and 10 between the window 311 and the top 11 of the cartridge 1 to form a fluid tight seal of sufficient integrity to withstand the pressures developed during the operating cycle.

To commence the operating cycle the consumer operates the start/stop button 241.

15 The operating cycle comprises the steps of cartridge recognition and the discharge cycle.

Cartridge recognition is performed by the optical cartridge recognition means 252 as described above assuming that the outputs from the cartridge sensor and lock sensor 20 are satisfactory. Once the barcode 320 has been decoded the operational parameters of the machine 201 are adjusted by the control processor. The discharge cycle is then automatically commenced.

The discharge cycle has four main stages, not all of 25 which are used for all beverage types:

- (i) Pre-wet
- (ii) Pause
- (iii) Brew/Mixing
- (iv) Purge

30 In the pre-wet stage the cartridge 1 is charged with water from the water storage tank 220 by means of the water

pump 230. The charging with water causes the beverage ingredients 200 in the filtration chamber 130 to be wetted. The charging may take place at a "fast" flow rate of 600 ml/min or a "slow" flow rate of 325 ml/min. The slow 5 charging rate is particularly useful for cartridges containing viscous liquid beverage ingredients where the ingredients require some dilution before they are able to be pumped at a higher volume flow rate. The volume of water injected into the cartridge 1 is selected to ensure that 10 water or beverage does not drip out of the cartridge outlet 122 during this stage.

The pause stage allows the beverage ingredients 200 to soak in the water injected during the pre-wet stage for a predetermined period of time. Both the pre-wetting and 15 soaking stages are known to increase the yield of the extractibles from the beverage ingredients 200 and to improve the end flavour of the beverage. Pre-wetting and soaking are particularly used where the beverage ingredients are roast and ground coffee.

20 In the brew/mixing stage water is passed through the cartridge 1 in order to produce the beverage from the beverage ingredients 200. The temperature of the water is determined by the control processor which sends instructions to the water heater 225 to heat the water passing from the 25 water tank 220 to the cartridge head 250. Water enters the lower part 255 of the cartridge holder 251 through the conduit 262 via the inlet valve and the inlet piercer 253 into the inlet chamber 126 of the beverage cartridge 1. Brewing and/or mixing and subsequent dispensing of the 30 beverage from the beverage cartridge 1 is as described above with reference to the versions of the beverage cartridge 1.

The air purge comprises the blowing of pressurised air through the beverage preparation machine and the beverage cartridge 1 to ensure that all beverage is dispensed and that the flow path is cleared ready for dispensing another 5 beverage. The air purge does not commence immediately on cessation of the brew/mixing stage to allow for the majority of the fluid to clear the flow path. This prevents an unacceptable spike in internal pressure on commencement of the air purge.

10 In normal operation a user manually stops the machine 201 by operating the start/stop button 241.

Once the operating cycle has been completed the consumer removes the cartridge 1 by opening the cartridge holder 251 and manually removing and disposing of the 15 cartridge. Alternatively, the machine 201 may be provided with an automatic ejection mechanism for removing the cartridge automatically on opening the cartridge holder 251.

The delivery times for beverages using the machine 201 and cartridges 1 are typically between 10 and 120 seconds, 20 preferably 30 to 40 seconds for roast and ground coffee, between 5 and 120 seconds, preferably 10 to 20 seconds for chocolate and between 5 and 120 seconds, preferably 10 to 20 seconds for milk.

The machine 201 may also advantageously comprise a 25 memory in operative communication with the control processor that stores information on the type of beverage dispensed by a user. The operating cycle of the machine 201 may then be adjusted for the next cartridge 1. This is especially advantageous where two or more beverage cartridges 1 are 30 used sequentially to form a beverage. For example a coffee cartridge may be dispensed followed by a milk cartridge to

form a cappuccino beverage. Alternatively a chocolate cartridge could be used followed by a milk cartridge to produce a creamy hot chocolate beverage. By using a memory that stores information on the first beverage dispensed, the 5 manner of dispensing the second cartridge, say a milk cartridge, may be altered to achieve an optimum beverage. In the above example the milk dispensed for hot chocolate may, typically, be diluted less than the milk added to the coffee. In addition, the milk dispensed for chocolate may 10 be dispensed at a slower flow rate to lessen the degree of foaming of the beverage. Many combinations of cartridges are possible and operating parameters as will be obvious to the skilled person. In addition, the memory may be used to allow the machine 201 to 'predict' the type of beverage that 15 a user will next want to dispense. For example, if a user predominantly drinks one beverage type then the machine can instruct the water heater to remain at the optimum temperature for that beverage type.